Seeing and feeling in VR: bodily perception in the gaps between layered realities

Lisa May Thomas[1,2,3,4,*] & David R. Glowacki[2,3,4]

[1]Department of Theatre, University of Bristol, Cantock's Close, Bristol BS8 1UP, UK; [2]Dept. of Computer Science, University of Bristol, Merchant Venturer's Building, Bristol BS8 1UB, UK; [3]Centre for Computational Chemistry, School of Chemistry, University of Bristol, Cantock's Close, Bristol BS8 1TS, UK; [4]Pervasive Media Studio, Watershed, 1 Canons Rd, Bristol BS1 5TX, UK

*lt15256@bristol.ac.uk

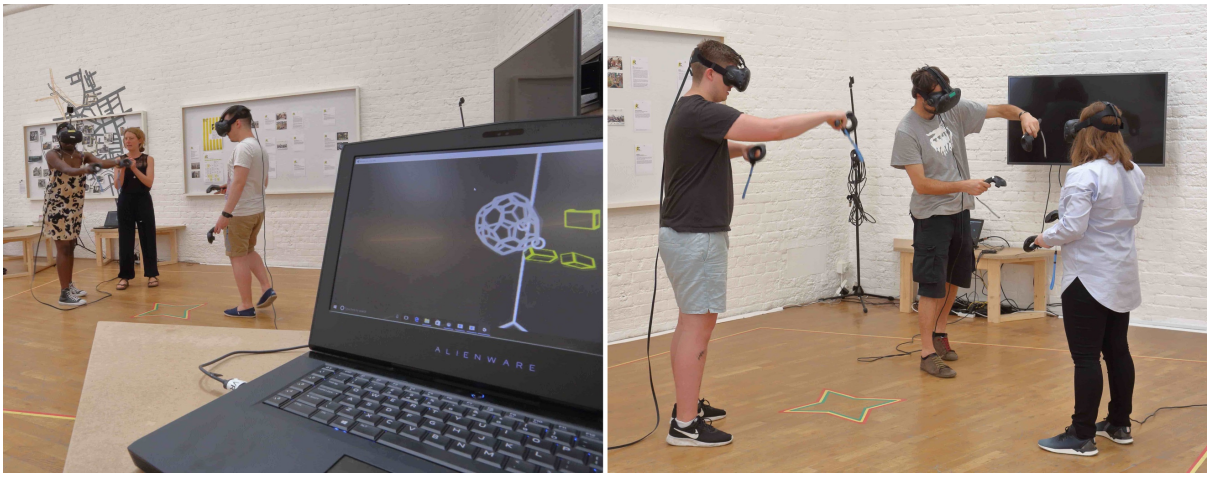

Figure 1: Artist-researchers Lisa May Thomas (center, left panel) & David Glowacki (center right panel) guiding audience-participants through multi-person VR workshops (photo courtesy of Stu Allsop, taken during the "Future Knowledge" program at Modern Art Oxford, curated by Emma Ridgway)

Abstract: This essay explores the layering of perceptual information across the real and the virtual that occurs when bodies cohabit virtual environments using new commodity-priced virtual reality technologies. Specifically, we take an embodied somatic and dance perspective to better understand and characterise the perceptual gaps between how bodies are seen and how they are felt in virtual environments. Our discussion derives from observations and analysis of participant feedback obtained from a series of workshops run in July 2018 using a new multi-person VR framework. This research has opened up a fascinating fundamental question: can we harness VR's potential to awaken new modes of perception that enable people to better know their body?

Keywords: Somatic, Sensory, Embodiment, Virtual Reality, VR, Touch, Vision, Practice-as-Research, Performance, Technology

1. Introduction

Humans have always had the propensity to physically be in one place and to *imagine* being situated in another. Cinema, immersive theatre, puppetry, digital performance, religious ritual, and meditation practice are all examples of practices which create spaces and cultures of how *virtuality* can be *imagined* and *represented,* and which can transform or transport the bodies of participants or audiences. In 1938, Antonin Artuad described the illusory nature of characters and objects in the theatre as *la réalité virtuelle* in a collection of essays entitled *Le Théâtre et son double* (49: 1958). The construction of virtual spaces and the dynamics of the bodies within and outside of those spaces are essential areas of research for performance and theatre makers. Artuad wrote about the way in which theatre renewed life's meaning by rejecting normative "limitations and powers… infinitely extends the frontiers of what we call reality" (7: 2010). A participant who is transported to a virtual environment (VE) using virtual reality (VR) technologies is arguably not merely transformed, transported or extended but instead undergoes an intrinsic sensorial re-wiring.

Artaud for example describes a plague epidemic as an unseen and virtual phenomenon that enters into the dreams and nervous systems of the bodies of the people in a city (Marseille), which he casts as a metaphor for the virtuality that is conjured in theatrical practice; "Just like the plague, *it* [theatre] reforges the links between what does and does not exist, between the virtual nature of the possible and the material nature of existence" (18: 2010). In VR-based VEs, there is a *layering* of the visual virtual environment onto the physical environment. The physical environment has not gone away; rather it serves as a sort of background to a more dominant visual virtual experience which 'takes over' the sensory domain. This is a sort of disruption, but it also mediates continuous dialogue between the real (body) and the virtual (environment).

There is a sense in which the VR headset or head-mounted-display (HMD) acts like a blindfold which blocks out all visual information of the "world-out-there" - and blindfolds in fact offer an interesting analogy by which to understand the sensorial re-wiring that occurs within VR. On the one hand, the blindfold can easily be interpreted to represent a sort of dystopia whose very design enforces troubling power asymmetries, as shown in the well-known image of Facebook CEO, Mark Zuckerberg, at MWC in 2016[1]. One reading in the February 2016 edition of *The Verge* of this figure sees "[a] billionaire superman with a rictus grin, striding straight past human drones". On the other hand, blindfolds are commonly used within somatic and improvisation-based dance practices to facilitate forms of sensory awakening which can lead to an increase in the agency of the dancer through a more sophisticated sensory orientation and navigation of body and environment. As a training method that de-emphasizes visual form, blindfolds (or simply eyes-closed practices) encourage expanded ways of seeing, re-adapting the sensory system toward modes of perceiving one's own body, other bodies, and space, thereby freeing up visually imposed boundaries and generating the capacity to experience *felt* body-to-body and body-to-environment connections.

With the blindfold on, people and things which are present (but unseen) are no longer sensed as forms or surfaces which are static, identifiable, fixed or separate entities, but rather as continual relational processes – forms of human and nonhuman matter which can materialise in ways which are entirely reconfigurable. Without vision, other senses come to the fore in orienting and navigating the body – e.g., kinesthetic, proprioceptive and tactile senses which govern bodily position, movement, balance and touch. *Seeing* no longer belongs solely to the eyes and therefore emerges as a less objectifying and more a felt and empathetic sense: the body *sees* into and beyond its borders, and also into other bodies. Through blindfolded

[1] https://www.youtube.com/watch?v=Avauvgie4lc

practices, a somatically trained performer eventually retains a perceptual communication with a non-visual flow of sensory input, enabling her to move, orient within, and navigate non-visual spaces, even whilst the eyes are open.

In this essay, we take an embodied somatic and dance perspective to understand the *layering* of perceptual information across the *real* and the *virtual* that occurs when people enter into VEs using VR technologies[2]. Specifically, we aim to better understand and characterize the *perceptual gaps* between what is *seen* and what is *felt*[3] in VEs. In order to facilitate this discussion, it is important to first outline precisely how we use the term 'virtual reality' and 'virtual environment', owing to the fact that they refer to a wide range of experiences and technology. For example, Steve Anderson writes about his frustrations around the imprecision with the contemporary use of the term 'Virtual Reality' or 'VR', because these terms tend to flatten distinctions among a diverse range of media practices. He suggests that the primary utility of this flattening lies in the realm of marketing and promotion (*Technocinema*, March 2016). Anderson draws attention to Scott Fisher who has resisted using the term 'Virtual Reality' in favour of the more location-specific phrase 'Virtual Environment'. Fisher suggests that to specify a 'Virtual Environment' is to locate or situate it rather than present it as another version of 'reality' as "[f]or most people, "duplicating reality" is an assumed, if not obvious goal for any contemporary imaging technology" (1: 1991).

VEs that participants enter into using VR technologies can be broadly split into two categories: those in which the *user* or *participant*[4] is *connected* i.e., can reach out and touch the "fabric of whatever world it is" (2017: 128, Lanier) and those in which they are *disconnected*. In our view, strapping a screen to your head does not necessarily qualify as 'virtual reality', unless you also have the ability to reach out and touch that world. This perspective is aligned with other authors, including Jaron Lanier (who has been referred to as 'The Father of Virtual Reality') who writes, "[i]f you can't reach out and touch the virtual world and do something to it, you are a second-class citizen within it… a subordinate ghost that cannot even haunt." (2017: 128, Lanier). In so-called 'virtual reality' systems like the 'google cardboard' and the 'Samsung gear', you are mostly an observer with no agency to reach out and touch the environment. In our view, these sorts of technologies are essentially forms of spherical video – i.e., extensions of film-making and viewing in which the frame is not confined to a 16:9 or 4:3 aspect ratio, a point we discuss in further detail later.

The VR framework used in this research, illustrated in Figure 1, is one in which (multiple) participants can *move* and *interact* with one another, and reach out a touch the simulations within the VE. To date, this framework has primarily been used and applied as a tool for scientific research and education – e.g., enabling researchers and educators to enter into, interact with, and manipulate real-time 3d molecular simulations at the nanoscale.[5] To date, research into this framework has almost exclusively focused on technical details – i.e., the computational physics, simulation algorithms, network latencies, cloud compatibility, and various other computer science aspects of the setup. The research outlined in this particular

[2] Virtual Reality technologies aid a person to explore and interact with a computer-generated environment. Using these technologies, typically a headset or head-mounted display (HMD) is worn and controllers are held in the hands, the person becomes part of this virtual world or is immersed within this environment and is able to manipulate objects and/or perform a series of actions within it.

[3] The 'splitting up' of sensory phenomenon, into the *seen* and the *felt*, is a working hypothesis as to some extent it is a superficial distinction owing to the fact that the senses operate as an integrated and adaptable whole/system. However, it is necessary to make this split in order to break-down and problematize the complex issues around the sensory body in the virtual environment.

[4] I will address where possible the people using the VR technologies as 'participants' but will occasionally refer to them as 'users'. The latter is borrowed from the field of Human-Computer-Interaction (HCI) whilst the former is used more in performance contexts. See Bishop, C. *Participation* (2006)

[5] See https://arxiv.org/abs/1801.02884

article marks a departure from that previous work. It focusses instead on the somatic and sensory experience of bodies when they are using the framework, in order to speculate on potential applications in a broader range of areas beyond scientific research, including artistic and performance applications.

By understanding more about the ways in which the body is *seen* and *felt* in a VE - its visual nature and tactile capacity - we speculate on whether it might be possible for VR experiences to awaken different ways in which people *know* their body and what the wider implications might be of such perceptual re-awakening, strengthening, and training. Relinquishing vision to the blindfold is inevitably entangled with issues of control, power asymmetry, and vulnerability. The question, therefore, of identifying robust ethical frameworks which can help to guide how we craft the experiences of bodies in VEs is a crucial one. Whilst ethics is not covered in depth in this essay, it has been discussed in detail in a recent article entitled *Real Virtuality: A Code of Ethical Conduct. Recommendations for Good Scientific Practice and the Consumers of VR-Technology* by Michael Madary and Thomas K. Metzinger, 2016. The article highlights some of the key ethical issues which the participation in VR technology brings about. Madary and Metzinger write, "VR is a technology, and technologies change the objective world. Objective changes are subjectively perceived, and may lead to correlated shifts in value judgments" (1: 2016). One of the key issues considered in the article, and which draws insight from modern experimental psychology, is the plasticity of the human mind, "capable of being continuously shaped and re-shaped" (4: 2016), and the notion that human behaviour is "sensitive to environmental features" (4:2016). The authors assert that "VR technology will eventually change not only our general image of humanity but also our understanding of deeply entrenched notions such as "conscious experience", "selfhood", "authenticity", or "realness"' (1-2: 2016). In reporting on our research, whilst ethical concerns are discussed, it is the thorough investigation into what it means to be a body in a VE using VR technologies that we focus on. This research will certainly lead on to further insight and recommendations into the ethical considerations for these bodies and how dance and somatic practices might play a role in this discourse. We believe that the sort of questions investigated herein – of what it means to be a body in a VE using VR technologies – will certainly help in understanding and formulating appropriate ethical frameworks moving forward.

2. Methodology

The bulk of the analysis in this article is based on a series of experimental workshops which we carried out as part of the *Bodily Undoing* Symposium at Bath Spa University in September 2017. Specifically, we staged two separate workshops (each one hour long) with twelve participants taking part in total (six per workshop). The workshops consisted of a 40-minute practical session which involved entering into the VE, followed by a 20-minute group discussion,[6] enabling us to obtain qualitative feedback related to the following questions:

- How is the body seen and felt in the VE?
- What do we learn about different ways in which people *know* their bodies, both inside and outside of VEs?
- What are the wider performance and artistic implications?

The *Bodily Undoing* workshops were designed following extensive observations of different participants at a range of events between January and July 2017, including: (1)

[6] No specific information was disclosed about the nature of the VR technology/system in its function as a scientific tool, and the boundaries of the space and safety concerns were addressed - the main concern in terms of the technology and outlining the spatial boundaries was to make sure participants did not touch the lighthouse cameras at any point as this would create a disturbance with the technology.

scientists and engineers from our VR research lab at the University of Bristol; (2) public participants taking part in the interactive VR installation at *We The Curious* science museum (Bristol) and *Modern Art Oxford* showcase events; and (3) a select group of dancers who applied to take part in *dancer labs* at the *Arnolfini* contemporary art gallery (Bristol). Our observations of the ways in which these groups interacted within the VR technology, and with each other, raised broad questions concerning what it means to be immersed in an interactive simulated virtual/digital environment, and the *Bodily Undoing* workshops were crafted as a starting point in order to begin to unpack the implications and relations of the human and nonhuman bodies involved in these interactions.

Specifically, we noted a difference in the way in which the Arnolfini dancers (compared to other groups) responded to being in the VE, a result of their somatic (first person) sensitivity to their moving, sensing body. Their responses were mainly centered around the issue of *not having a body*[7] in the VE, and experiencing their bodies as *felt* but not *seen.* The *Bodily Undoing* symposium, whose stated aims were "to address the socially and cultural transformative potential of somatics and transdisciplinary performance practices" (Bodily Undoing programme, 2017, Kampe et al.), provided an excellent opportunity to further unpick the dancer responses obtained at the *Arnolfini*. *Bodily Undoing* participants were practitioners, artists, and scholars who work with somatic practices within the field of dance (the participants had little knowledge or previous experience in VR).

To further explore the gap between seeing and feeling, the *Bodily Undoing* workshops drew from somatic practices common to dance, specifically those which deal with approaches to (and adaptations of) *seeing* (this is discussed in further detail below). We hoped to discover what might be exposed when these practices are disrupted, mediated, and adapted through material and digital processes. The workshops followed a script we developed in order to guide participants through a series of task-based practical exercises and reflections. Each task invited participants to take a somatic-sensory focus through different *real* and *virtual* layers of the space/environment. There was a specific emphasis on *seeing*, with each task encouraging participants to explore the space/environment, as well as the human and nonhuman bodies within that space/environment. The participants were guided through six tasks:

(1) Explore the physical space and its contents with the eyes. Participants were asked specifically neither to close the eyes nor to touch anything but to notice the visuality of their physical environment, and the people and the technology within it - to notice colour, light and dark, shade, shape, texture, and boundaries.
(2) The lights were turned off, and participants were invited to sit together in the dark, keeping their eyes open.
(3) Each participant then found a partner. One of the pair was blindfolded whilst the other acted as a support, to guide if needed, keeping them safe and witnessing their experience. The pair's journey was led by the person wearing the blindfold, who was invited to explore and to *see* the space through touch and through the body.
(4) Still in pairs, the supporting partner placed the VR HMD over the blindfold enabling the person wearing the HMD over the blindfold to experience its physicality, including the wire connecting the HMD to the computer.
(5) The blindfold under the HMD was removed, with an invitation to explore the VE. Participants were instructed to move to find the edges and the ground, to explore and

[7] Using the multi-person VR framework at this stage in its development, the user's body was represented in the VE as a transparent rectangle which is mapped by the camera from the headset worn (see Figure 3). This meant that users could only see each other, not themselves visually in the VE. More generally, the ways in which the body of the user is represented in a virtual environment can range from having no avatar whatsoever, to a basic shape to much more complex human and nonhuman aesthetic forms.

notice what is moving in the VE and how it moves. The person acting as a support and a witness continued in this role whilst their partner moved in the VE.

(6) Once both people in the partnerships had experienced both roles, the group took time together to return to the physical environment, and to notice how it might have changed for them compared to the start of the workshop.

After these practical sessions had taken place, there was a group discussion in which participants were invited to share their reflections and responses to the workshop experience and asked to describe how they *felt, sensed, and moved through the different layers of space,* and *the physical, somatic, sensory qualities of the body - in particular the senses of vision and touch.* To analyse these group discussions, we carried out thematic analysis.[8] This style of analysis is a "widely used qualitative analytic method within psychology" (77: 2006) for "identifying, analysing and reporting on patterns (themes) within data" (79: 2006). Through the process of working through the workshop sessions via recorded images of the practical session and audio capture of the discussions, all emerging themes were identified and noted. There was then a process of merging some of the themes into broader groups or categories and lastly a selection process in terms of deciding on which of these categories to report on. This selection was based on two elements: Firstly, the relevance of the category and its themes in relation to the research questions in this early phase of the research (with an awareness that further research phases would follow, and that some of the themes would be picked up during these latter stages). Secondly, the emphasis placed around the importance of the theme or category as it occurred in the workshop was a key factor in this decision-making process.
These categories that were grouped, each containing one or more themes were as follows:

i) The permission participants felt they had to do things in the different sections of the workshop;
ii) How the conventions of touch differed in the blindfold to in the physical, visual space;
iii) The orientation and navigation of bodies, and the ways in which participants found the edges and the floor as places from which to orient and navigate themselves;
iv) The use of hands as the normative mode for touch (rather than other body parts);
v) The act of seeing in VR, with no possibility for peripheral vision;
vi) The sense of touch as dampened or removed in the VE, and the role the controllers played in this lack of tactility for participants;
vii) The materiality of the VR technology and how that felt to the participants;
viii) The perceptual gap between vision and touch, and how things did not correlate to each other (e.g. the ground, other bodies etc);
ix) Seeing and recognising each other in VR, and the visual virtual body;
x) The use of imagery in the blindfold as lost in VR;
xi) Being guided into and coming out of VR;
xii) The presence of, and the way in which the molecules moved in the virtual environment;
xiii) The roles of being the witness or being witnessed;
xiv) Materiality and the physical space;
xv) Collisions through touch moments as not seen and so not pre-empted in VR;
xvi) The (witnessed) slowness of the movement of participants in VR;
xvii) The felt sense in VR, there being a definite feeling or sensation in there, sense of floating, gravity, thickness;
xviii) The multi-person framework;

[8] See Braun, V. & Clarke V. *Using Thematic Analysis in Psychology* (2008)

xix) The boundaries of the physical and the virtual space;
xx) The sound.

The predominant theme that was selected was *viii) The perceptual gap between vision and touch, and how things did not correlate to each other (e.g. the ground, other bodies etc);* This theme was of relevance to the research question and mapped with prior observations of other dancer-somatic groups of practitioners. This theme also belonged with associated responses which directed much of the group discussion in one workshop. This theme is written about in section 3. and the associated responses made by participants are detailed as 'ways of knowing the body' and form the basis for section 5. Theme xviii) *The multi-person framework* was referenced throughout both workshops and was selected as an important theme to report on due to the unique capacity for this VR framework to enable a shared VR experience between co-present participants. In particular the ways in which participants recognised each other in the VE (theme ix) *Seeing and recognising each other in VR, and the visual virtual body*). This is discussed in section 4. alongside other key themes which collectively brought up some of the fundamental issues of shared participation in VR (such as, convention, permission, orientation and navigation, and boundaries). The themes which pertain more to the *felt* sensations of participants (which include sensations of thickness, the slowness of the movement of participants in VR, and the presence and movement of the molecules) will be further investigated in ensuing research workshops (please refer to the concluding section). Finally, there are themes that will come into focus in the latter stages of this research, after the workshops and their analysis has taken place. These themes will be further investigated through the development of participatory-performance work (these themes include, for example, are the role of being the witness or being witnessed; being guided into and coming out of VR; materiality and the physical space; and sound amongst others).

3. The Perception Gap: Existing Theories and Practice

The *layering* of a visual VE onto the physical environment does not mean that the physical environment has gone away, but rather it now serves as a sort of background to a potentially more dominant virtual visual experience. There is a sense in which the body is in two places at once, with layers of perceptual information received by the body from both the physical environment and the VE. This layering seems to involve two processes: Firstly, perceptual mechanisms which inform bodily reactions to the visually perceived environment or virtual body (specifically the visual information received through the HMD) override the cognitive understanding or knowledge that the virtual world is not real. (Slater, 2010). Secondly, within the perceptual system itself, vision overrides other sensory input into the body. What is seen as *virtual* layers over what is known or felt as *real* or *physical*.

To better integrate these layers, "Many researchers argue that the next step in VR is to allow users to not only see and hear, but also to feel virtual worlds. Researchers initially explored the use of mechanical machinery for that purpose, such as exoskeletons or passive, robotically actuated props" (Cheng et al., 2017: 1). Most VR systems and technologies work in various ways to control the extent of the perceptual gap between seeing and feeling, using a range of methods. For example, constructing VR experiences which are relatively sedentary with little movement reduces the likelihood of feeling or touching anything that is not seen. Another approach is to construct modes of moving and touching in VR in which the system is designed to incorporate what is felt as something that is seen, so that the VE mimics the physical. Attempts to reconcile the gap between what is seen and what is felt using this 'mimicking' effect include The Haptic Turk system. Developed by Researchers Lung-Pang Chen, Sebastian Marwecki, and Patrick Baudisch, it uses 'Human Actuation' to assist the sense of touch and

enable users to move, push and pull objects in VR, in order to encourage the user 'further in' to the virtual, engaging more of their senses.

In *First Person Experience of Body Transfer in Virtual Reality* (2010), Mel Slater writes about experiments using VR to inhabit a virtual body other than one's own. His results add weight to the notion that the sensory system (where vision tends to dominate)[9] can "override" (1: 2010, Slater) a cognitive *knowing* and create "a radical illusion of transfer of body ownership" (1:2010, Slater). Slater's "research also shows that immersive VR can be a powerful tool in the study of body representation and experience, since it supports experimental manipulations that would otherwise be infeasible, with the technology being mature enough to represent human bodies and their motion" (1:2010, Slater). As vision is dominant in the sensory system, the mimicking of virtual and physical objects (via human or nonhuman actuation), and the representation of the user's own body can enable this perceptual *transfer* from the physical to the virtual. The mimicking effect provides a like for like (or like for very similar, as it never *exact*), from real to virtual, so that a user can fully 'be in' (and believe in) the virtual version, and (on some level) leave the real behind. There is less of a tension between what is seen and what is felt because the experience exists in a virtual monospace whilst the physical world is somewhat left behind. If the screen in the headset has a glitch or there is some latency in the system (or the distraction of background sound without noise cancelling headphones[10]), cognition kicks in to say that 'this is not real'. When it comes to bodily transfer, technologies are finding more and more ways to reduce this 'gap'. Because the mimicking is never exact, the user will always be operating from the boundaries of a body that is different to his/her own. When the physical and virtual are not mimicked but are instead changed in some way - for example the size, scale or location of a body or a thing - the transfer of perception can still be effective.[11]

In this article, we are less concerned with exploring a complete transfer of body and environment to the virtual. Instead we are interested in understanding the impact of layered perceptions and realities. Sita Popat's writings about her layered sensory experiences of participating in and navigating a reconciliation with her 'missing body' in *White Island* (a VR work by Ruth Gibson and Bruno Martelli, 2014) offer a particularly interesting case study in this respect. White Island draws on S. A. Andrée's doomed polar balloon expedition of 1897, in which Andrée's balloon crashed on the ice near Kvitøya (White Island). The three expedition members perished and their final campsite was only located in 1930. Consulting textual and photographic documentation left by the original expedition members, Gibson/Martelli built a computer generated world using height map data and game engine technology (Gibson and Martelli, 2014). The *White Island* installation is an interactive VE which uses a VR headset, a custom-built interface (comprised of a rope and an electric fan), and surround sound. The headset is tethered high so as to hang down and then can be lifted onto the heads of participants. It uses a bungee cord for strain relief when the participant is in motion. This would take away any touch of the cord to the rest of the body and create the illusion of having no restriction with head motion. A rope which is held in tension between two springs utilizes a proximity sensor to measure up-down motion and an accelerometer to measure left-right motion, both of which are attached to an Arduino. Electric fans are mounted on metal ring above the participant's head and are attached to the Arduino/Relay setup.

[9] Vision can be certainly considered as the dominant sense in the Western body but see Montague, A. *Touching: The Human Significance of the Skin* (1986) for an anthropological analysis of the Aivilik Eskimo tribe who train tactile and aural as former sensory responses to vision.

[10] Sound in the VE is an area that is currently being investigated by Alex Jones, an audio engineer who is a member of the Glowacki research group at the University of Bristol

[11] See *Rubber Hand Illusion* Passingham et al. (2005)

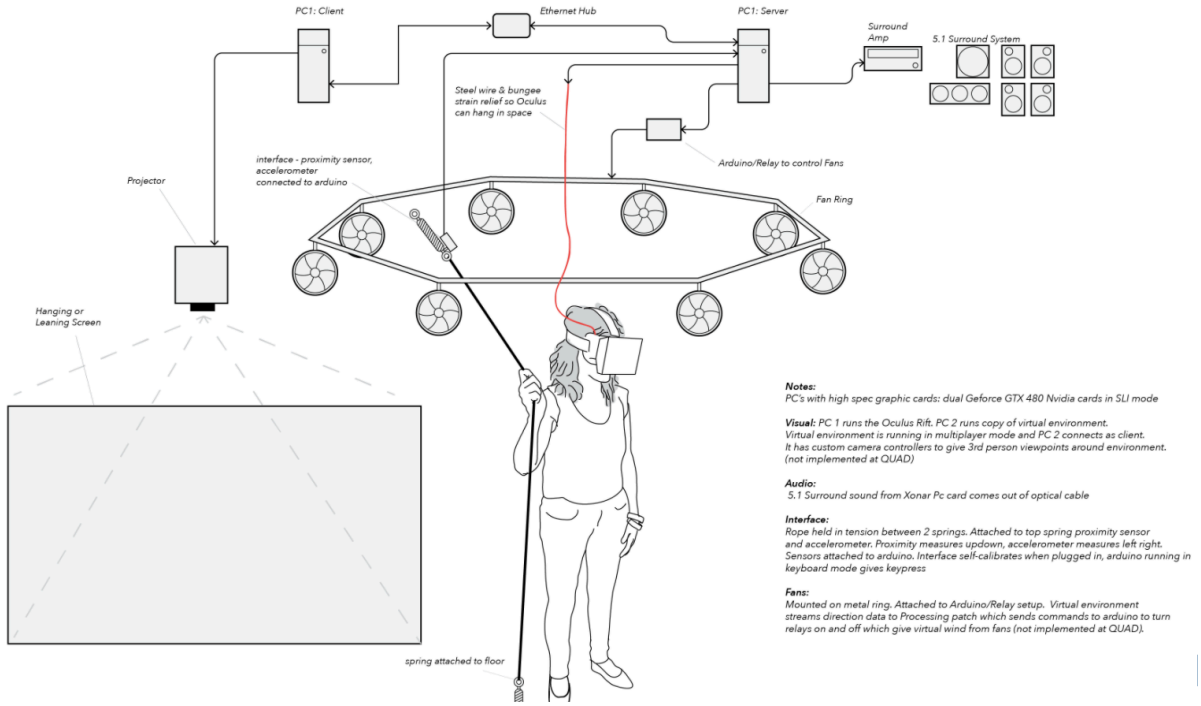

Figure 2 Set-up for White Island (2014)

Popat's description of entering into the VR experience is as follows:

> In July 2014, at the Coleman Project Space in East London, Martelli showed us into a small, dark room, the walls hung with heavy black cloth. A thick, rough rope was stretched vertically floor-to-ceiling, attached at the base to a stage weight and at the top to a metal rig. Next to the rope was an Oculus Rift headset, dangling by a wire from the overhead rig. He told us that we could tug down on the rope to gain height and pull up to lose height (Popat, 2016: 361).

In her experience of her body as felt but not seen and the environment in which her body was located as seen but not felt, Popat refers to the body as both absent and present. Instead of a duality in her experience of physical (felt) body and her virtual visually missing avatar, her experience was of "a single subject with blurring boundaries and definitions" (Popat, 2016: 371) and she describes the physical-virtual binary as "indistinct in the blurred body"(Popat, 2016: 371). The distinct touch and pull of the rope moving her between physical and virtual realms feels like a bridge between through which she could navigate her journey. The touch of her hands to the rope and of her feet on the ground served as points of reference, of orientation.Through this layered experience, Popat suggests that perception is a slippery, mutable place of confusion, of blurriness, of neither a here nor a there: "*White Island* was neither bodily nor metabodily anchored" (Popat, 2016: 371). Popat's physicality is strongly present through her experience of a visual VE through which she needed to navigate her unseen body. Her body being not *seen* but *felt* encouraged her to 'listen' more sensitively to proprioceptive and tactile signs and sensations of balance, movement, and touch. The missing or absent body in the visual VE highlighted this felt presence and created a need for processes through which she could locate her body without relying on the visual. Popat's observations

here are entirely consistent with evidence in the medical literature showing that VR improves sensitivity to proprioception[12].

The sensory processes to which Popat attuned her experience of her unseen felt body in *White Island* resonate with somatic training processes used in dance practices. As mentioned in the introduction to this essay, dancers utilize the blindfold to offer up expanded ways of seeing, through a re-adapting of the sensory system toward more *synaesthetic* modes of perception.[13] Form becomes fluid, malleable, deep, and penetrable: Human and nonhuman matter materialise "in their ongoing iteratively intra-active reconfiguring" (Barad, 2012: 77). Without vision as a driver, the kinesthetic, proprioceptive and tactile senses which govern bodily position, movement, balance and touch come to the fore in orienting and navigating the body. *Seeing* no longer arises solely from the eyes, but also from the body. It becomes a less objectifying and more a felt and empathetic sense. With time, this training enables the dancer to move with their eyes open whilst retaining a perceptual communication with the non-visual flow of sensory information and to navigate non-visual spaces. Training methods such as *flocking*[14] (used in dance and theatre ensemble practices) do not involve closing the eyes or using a blindfold, but nevertheless operate in a similar way – i.e., opening up vision in order to incorporate other sensory modalities for navigating bodies and spaces.

Contact Improvisation (CI)[15] practitioners tap into the sensory flow of proprioceptive acts through what has been called *The Small Dance* (1977, Steve Paxton). This attentional score requires a standing and an observing of the body as the automatic and unconscious micro reflexes dialogue and dance with gravity in their rise and fall. *The Small Dance* is an invitation for the dancer to move their eyes inward and to attend to the micro-movements of the body in continual response to the fall of gravity. The body moves in this way all of the time, but it is through this score that one attends to it. It is aimed at *attending* to *attention*:

> What we have is the senses and the really ordinary stuff - breath, the heartbeat and pulse. In the standing, we have the reflexes as easily observable events that the consciousness is not causing and can take a moment to wonder at. The standing is happening all over the body, so you get a full body event that you are watching, and one that you are not seeking; it is just happening. You have a thing to focus the mind on" (Paxton, 2015: 39).

The visual virtual world of *White Island* in which Popat's body was missing encouraged her to *attend* to the dynamical flow in her body. Unable to rely on visual cues, her experience of not having a direct visual representation of her body in *White Island* meant that she could better *feel* it. Her feeling, living, moving, breathing self was subjectively experienced through the proprioceptive senses coming into focus. Her *felt* body in motion was highlighted through its missing visual presence. The neurologist Oliver Sacks writes about proprioception as the "sensory flow from the movable parts of our body (muscles, tendons, joints), by which their

---

[12] In their 2014 paper *Development of Virtual Reality proprioceptive rehabilitation system for stroke patients*, Cho et al. (2014) analyse how stroke patients perform reaching movements and (stroke-affected) hand positioning toward a target position in VR with and without visual cues. They present quantitative evidence suggesting that VR can actually improve stroke patients' ability to improve proprioception lost during a stroke. They speculate that VR may offer "a new type of rehabilitation system" (263: 2014) which "focuses on the proprioception of stroke patients" by "blocking visual feedback" (263: 2014) "could be an effective means to enhance motor control during rehabilitation training" (264: 2014).

[13] see Machon, Sobchack, and Birringer on synaesthetic dance and performance practice.

[14] *Flocking* is an ensemble movement improvisation practice which draws from the behaviour exhibited when a group of birds are foraging or in flight

[15] Contact Improvisation (CI) is an improvised dance form in which orients around a point of contact usually between two dancers, but sometimes more, for more on this see Novack, C. (2015) *Sharing the Dance*

position and tone and motion are continually monitored and adjusted, but in a way which is hidden from us as it is automatic and unconscious" (Sacks, 1985: 26). Proprioceptive senses do not require any conscious attention and continue to operate in the background regardless of what is occurring. Lanier writes that "[v]irtual reality peels away phenomena and reveals that consciousness remains and is real. VR is the technology that exposes you to yourself" (55, 2017, Lanier). With the world and the body replaced (and experienced as 'different' visual virtual phenomenon), normative modes of perception (which tend to be based on what is *seen* given the dominance of vision in day-to-day perception) are disrupted. If the body, or the environment is *absent* – not black or internal as would be in a blindfold or with the eyes closed, but *missing* as Popat's body is in *White Island* – then what opens up as a result of disruption?

4. Responding to boundaries and other virtual bodies in multi-person VR

During the *Bodily Undoing* workshops, participants in the VE took a little time to register and locate themselves. To support the process of their entering into the VE, they were first invited to explore the environment spatially – e.g., finding the edges and the floor of the virtual space – mimicking what they had just done in blindfolds. They were unaware of the fact that they would be able to visually 'find each other', i.e. to see virtual avatars of other HMD-wearing people in the VE. In what follows, we provide some description of our multi-person framework, to enable the reader to better understand what occurred in the moments during which bodies first encountered one another in the VE.

White Island and most other VR experiences are solitary experiences. The user is typically alone in the physical space, and wearing a headset or HMD through which they are inhabiting a virtual space alone. If they are "with" others, then it tends to be either with simulated avatars, or else users who are physically remote to themselves and present via telematic interactions (e.g., online platforms for video gaming).[16] In typical VR contexts, bodies are rarely co-present. There are some platforms being developed which do operate a 'multi-player' function, such as Swiss artistic director and choreographer Giles Jobin in his new work *VR_1* (2018). In his piece, Jobin is attempting to connect the five participants who are inhabiting the VE together. The participants are free and encouraged to make physical contact with one another in both real and virtual environments. The press headline commenting on Jobin's work alongside two other VR pieces at Sundance is *Virtual Reality Gets Social*. The reporter, Josefina Buschmann, goes on to comment about the future of VR as that which can bring people together in shared experiences and that "[i]n spite of the emergent state of the medium, the future of VR seems to be social" (IndieWire, Feb 1, 2018). Buschmann goes on to ask the question: "What are the kinds of connections we want to experience in these social virtual spaces?" A key aspect of the VR framework used for the research herein is that it enables a number of people (up to eight) to be in the same space, simultaneously co-present in both the physical and the virtual environment[17] (shown in Figure 3 with two users). Crucially for the genre and for the people that are developing and using VR technologies, this research offers an investigation into the somatic and sensory experiences of relational bodies within multi-player systems. Understanding these sorts of issues and their emerging ethical implications will enable us to investigate the sorts of questions raised by Buschmann.

[16] Grau, O. writes in *Virtual Art: From Illusion to Immersion* (2003), VR about "the idea of installing an observer in a hermetically closed-off image space of illusion." (Also, one could mention *The Skinner* box here).

[17] https://arxiv.org/abs/1801.02884

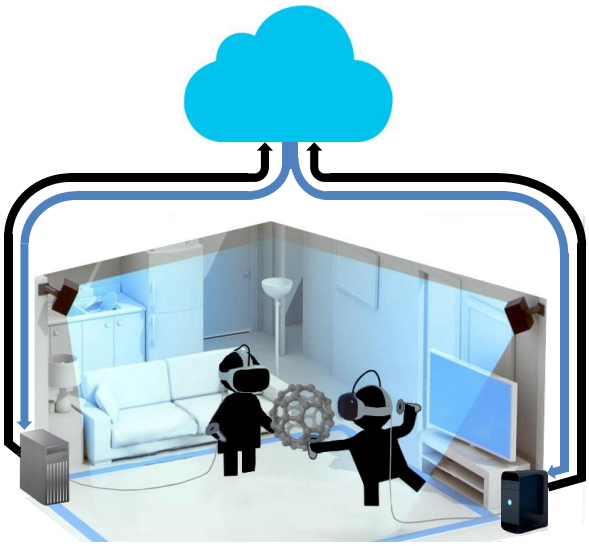

Figure 3: Multi-person VR framework setup in which bodies are co-present in the same space. This particular figure shows two people passing between themselves a simulated molecular object

In the VE used in this research, the "limits" of the virtual space are defined by an outline of blue gridlines (see Figure 4). These "limits" are not real limits; rather their primary function is health and safety, as a means of ensuring that users of the system do not go outside the boundaries and collide with things in the physical space which they cannot see wearing the HMD. During the *Bodily Undoing* workshops, the invitation to participants (once the blindfold had been removed from underneath the HMD) was to explore the VE, to move to the edges, and to find the ground. Despite being supported by their partners, participants commented on how "the space was so defined with the eye wear", (Participant, 2017: 9) and how the visual boundaries of the VE kept them within the restricted space. This is in contrast to being blindfolded, which some found "much more permissive" spatially (Participant, 2017: 9).

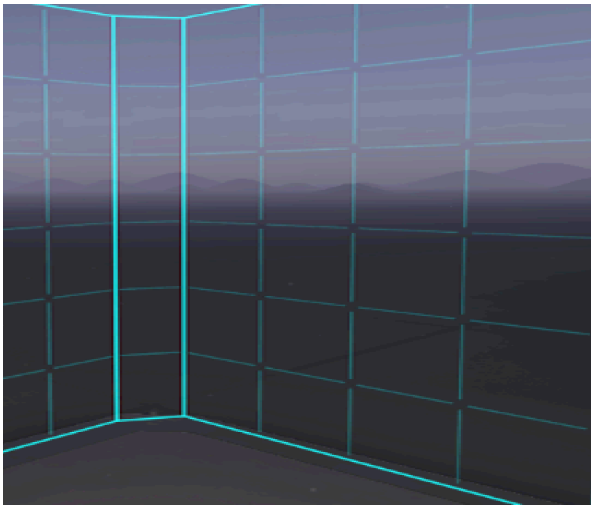

Figure 4: Blue grid which demarcates the boundaries of the VE

On seeing the boundaries shown in Figure 4, the participants wondered "what happens when I pass through that?" (Participant, 2017: 12) - what would happen if "I reached through" (Participant, 2017: 9) the boundaries or the "wall" (Participant, 2017: 7) in the VE. For one participant, the "imagination of science fiction films came in" (Participant, 2017: 12) and he

wondered "actually what happens if I step through this, you know, I'm not sure" (Participant, 2017: 12). He did not reach through. Another participant was wondering "what was on the other side" (Participant, 2017: 12) and how she should go about giving herself "grounds" (Participant, 2017: 12) for movement and interaction in this bordered place/space:

> I knew it was a machine and I knew… the machine's got some sort of instruction given to it, the colours and stuff like that, so I was poking… behind the grid and I was like what if I like put them on top, will I have because the sense of direction and space and depth were changed for me in this thing, so I was like how else can I give myself grounds, or how do you say this, grounds I guess, where would be my grounds, if I put my hand over here and then I put this one there and the drawings go like this, does the grid move? I was trying to reconstitute space frame (Participant, 2017: 12).

Despite the fact that participants had understood and experienced the broader perimeters of the physical space (through the prior tasks before entering into the VE);[18] none moved through the gridline boundaries. Whilst being in the VE potentially freed participants from the conventions of the physical world, their engagement with the grids as a 'border place' was restricted due to a sense of uncertainty. The movement and interaction in this 'border place' resonated with a sense of the 'other-wordly' conventions of science fiction, and notions of how space itself might be reconstituted – i.e., usual, physical (Newtonian) laws of space-time-matter existing in the physical realm might not apply in the virtual and thus the conventions for movement and interaction might also change. These participant comments are very much aligned with claims made by Ivan Sutherland in his famous essay *The Ultimate Display* (1965) which laid much of the groundwork for modern VR (2009), "[w]e live in a physical world whose properties we have come to know well through long familiarity. We sense an involvement with this physical world which gives us the ability to predict its properties well. For example, we can predict where objects will fall, how well-known shapes look from other angles, and how much force is required to push objects against friction": "A [VR] display connected to a digital computer gives us a chance to gain familiarity with concepts not realizable in the physical world. It is a looking glass into a mathematical wonderland" (1: 2009). One of the workshop participants commented about the sensation of 'floating' which is something that is not possible to achieve in the physical world:

> Something that I noticed… in the tangible world you don't get an opportunity to interact with "floating", just on a very basic level, we literally don't get the opportunity to interact with floating… but the sort of physics… was just a really interesting thing to interact with… to interact with somebody, something, in a way that I don't interact with anything else in this world (Participant, 2017).

Participants described sensations of weight, gravity and density in the space around them in the VE due to the effects of the (virtual) parameters. The white box and the blue grid made them feel "enclosed" (Participant, 2017: 7), which manifested in the sense of the space having "density" (Participant, 2017: 7), as though "the air was slightly thicker" (Participant, 2017: 7). The sense of the "thickness" of the virtual air" affected how participants sensed not only the space around them but how they felt their unseen body within such an environment. One

[18] Participants were told to explore the virtual environment in this task, there was no mention of the grids or what the grids were for (as a safety mechanism to stop people walking into physical walls or objects they are not able to see in the virtual environment).

participant described a sensation that her 'Kinesphere'[19] "shrinks in response to that virtual world" (Participant, 2017: 7). The sensations of *thickness* and *shrinking* are *felt* or responses to a moving and responsive visual environment. Seeing emerges as a sense which is inherently tactile in this responsive, visual environment – due to the relationship between seeing and feeling or tactility, and also due to the movement / responsivity of the visual environment (this *felt* or tactile sensation will be further investigated in the next phase of this research, please see the concluding section which details these next steps).[20]

At this early stage of our research, we have been rendering (visually) the HMDs of other participants as simple rectangles (see *Figure 5*). The movement of the rectangles in the VE corresponds perfectly to how participants are actually moving their heads, as the position and orientation of the HMDs are tracked by the system via embedded sensors. This ability to see others' heads as rectangles enabled participants to imagine their own heads as rectangles, and connect the motion of other rectangles to the motion of their own and others' heads; "as soon as I saw that these other floaty heads I was like ahhh that's me, like I have friends in this world that I am here with" (Participant 2017: 4).

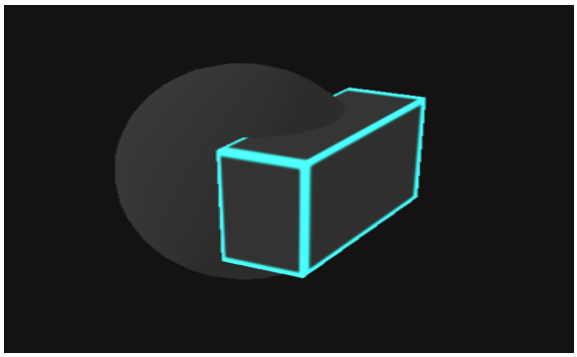

Figure 5: How one user would have seen another user's HMD during Bodily Undoing (a simple rectangle)

Writing about the concept of presence in VR, Mel Slater along with others including Mark Hansen, points out "the common view" (Slater, 2005: 333) of how a participant's sense of presence arises in VR. Most people suppose that a sense of presence arises from the sense of being visually located and represented in a VE (rather than the physical location). Slater instead argues that it is in fact *movement* which is key to presence, and the key to embodiment and agency in the VE. Slater argues that "the reality of experience is defined relative to functionality, rather than to appearances" (Slater, 2005: 333). Along these lines, Kozel points out (*Closer*, 2007) that the virtual space is in fact a 'verb-space' – i.e., site for action and movement. The key to "the sense of *being there* in a VE is grounded on the ability to *do there*" (Slater, 2005: 333). It is movement rather than visual verisimilitude which is key to embodied agency in the VE, which we have also found to be the case in our previous practice-based research - e.g., the *Dances with Avatars* (2016) project, which was an adaptation of previous work with a cross-disciplinary group of collaborators.[21]

[19] The notion of Kinesphere was created by Rudolf Laban to define: "the sphere around the body whose periphery can be reached by easily extended limbs without stepping away from that place which is the point of support when standing on one foot" (Laban, 1966: 10).

[20] Also, see Abram, D. *Becoming Animal* (2010)

[21] (1) D. R. Glowacki, "Sculpting molecular dynamics in real-time using human energy fields," in *Molecular Aesthetics*, ISBN: 9780262018784 (MIT Press), ed. Peter Weibel and Ljiljana Fruk, Sept 2013; (2) T. Mitchell, J. Hyde, P. Tew, D. R. Glowacki, "danceroom Spectroscopy: at the frontiers of physics, performance, interactive art, and technology," Leonardo, 49(2), p 138-147, cover article (2016); (3) D. R. Glowacki, M. O'Connor, G. Calabro, J. Price, P. Tew, T. Mitchell, J. Hyde, D. P. Tew, D.J. Coughtrie, and S. Mcintosh-Smith, "A GPU-

Meeting others was something we left the participants to explore and figure out for themselves. For many of the participants, the moment of finding another co-present body in the VE was "exhilarating" (Participant, 2017: 8), shifting the experience from one which was initially solitary to one which was shared with a collective. Whereas in the blindfold, one participant felt self-conscious, and on her own in the experience, the sense of sharing the 'dark' space of the VE was transformative for participants, "You no longer really feel alone" (Participant, 2017: 4). The interaction between the represented 'bodies' of workshop participants in the VE occurred through movement (rather than touch) – colored rectangles hovering in empty spaces communicating through head motions such as tilting actions. Along these lines, it is interesting to note that a kind of "*bowing in"* ritual has arisen within our VR research lab at the University of Bristol: when groups of (often scientific) participants enter into the VE, they usually begin by taking turns bowing to one another, acknowledging one another's presence in the VE and offering an easy-to-understand means by for introducing new users to the notion that they can 'see' one another through nuanced attention to motion. As one of the *Bodily Undoing* participants remarked:

> The last part when we had VR headset on and I was given the instruction or the opportunity to say hello to the other people, I don't know who… I think [my rectangle] was green or yellow, now I forget the colour, but somebody else was there, we were just doing tilt [rectangle] left tilt [rectangle] right and that was the most exhilarating thing I've ever had in my life it was like a rectangle tilting sideways… I was trying to reconcile why a [floating rectangle] was so fun (Participant, 2017: 8).

Whilst being in the VE potentially freed participants from the conventions of the physical world, their engagement with the grids as a 'border place' was restricted due to an associated sense of uncertainty, and it was the unfamiliarity of the conventions of this 'world' which led them to take a 'safe' decision to remain within its virtual visual boundaries. Participants reported on a sense of *thickness* both in the space and within their own bodies as a result of the darkness and of their bodies as unseen by them. The propensity to move in slower and more resistant ways occurs when people are moving in very dark environments and is often associated with a shift in their perceptual field of attention, a *thickening*. This is an area that we plan to further explore in the next phase of this research (outlined further in the conclusions). For participants, the moment of meeting one another in the VE was transformative. Their experienced shifted from solitary to shared; and participants could imagine themselves visually as they saw each other (as rectangles which moved) which encouraged them to move more. Lanier writes about his experiments in how it is possible to shift the mapping of one's physical body in the motor cortex (the largest area of the cortex) to the virtual body of distinctly un-anthropomorphic like avatars. He dubs this *humuncular flexibility* (2017: 140, Lanier) and one of his many definitions of VR is as an "[i]nstrumentation to explore the deep time of nervous system adaptations and preadaptations" (141, 2017). The relationship between the visuality of the body and of others' bodies in the VE, and the aesthetic of this visual body, and the agency to move and interact for participants is something that will be further explored later in our research.

5. Ways of Knowing in the Perceptual Gap

accelerated immersive audio-visual framework for interaction with molecular dynamics using consumer depth sensors" in *Faraday Discuss*, Royal Society of Chemistry (2014) 169, p 63-87.

As has been discussed, there is a perceptual layering in VR with respect to sight and touch. The seen and the felt, two versions of sensory input which do not necessarily match up, are available simultaneously to the body, and the way in which this is reconciled (or not) by the body exposes different ways in which the body knows itself. Within both the dance-somatic bodies at the *Arnolfini* dancer labs and also at the *Bodily Undoing* workshops, there were two broad classes of (divergent) responses with regard to a 'knowing' of the (unseen) body in the VE. Dancer-participants indicated either:

a) Knowing the body without the need to see it in a visual form. Here there was a corresponding sense of freedom from the visual restraints that *seeing* the body brings; or
b) Needing to see the body to know it. Here there were accompanying sensations of dis-orientation, being unsupported by the ground, and weightlessness (because body/ground contact is unseen). This led to feelings of vulnerability and fearfulness, and a desire to find ground.

In the second *Bodily Undoing* workshop, there was a discussion between two of the participants (both of whom had dance/somatic backgrounds), each of whom experienced these different ways of knowing:

> Participant one: "I could powerfully feel the whole body, [be]cause I knew there was a whole body there and maybe because of the training we have, in somatics, I can feel where you were pretty much" (Participant, 2017: 9).
>
> Participant two: "I think what I found so disconcerting was that I couldn't see my own hands …I couldn't find any space to be because I kept seeking the wall and the wall wasn't there …it was just too much and so I just kept trying to seek, find a space and then seeing another person but also not knowing where your body is and not knowing where my body is, it's really overwhelming and slightly disconcerting for me" (Participant, 2017: 9).

Once the second participant was given controllers to hold in each of her hands (Figure 5), she then had some representation (see Figure 5) of the location of the arms and hands, and noted "It was a real relief" (Participant, 2017: 10). She had not liked being unable to see her own limbs or her hands, "when you gave me the handsets I was like thank God now this is a reference to my hands, my own body, there's agency in moving things around" (Participant, 2017: 10). The first participant was surprised at these comments. She had thought that the visual effect or representation for the limbs or the hands would not be needed if "you are somatically experienced" (Participant, 2017: 11). She was surprised at her "judgement" (Participant, 2017: 11) as she was so sure that her somatic background was the "reason why I was so comfortable not knowing where I am" (Participant, 2017: 11). In response, the second participant noted that it was "because I was relying on my visual sense, and then I couldn't see" (Participant, 2017: 10). Interestingly, participant two could easily operate in a non-visual sensorial way with the blindfold on, "I think when my eyes are closed I have a really strong sense of where my hands are" (Participant, 2017: 11). However, when the blindfold was pulled out from under the HMD she reverted to a visual mode of navigation; however, her inability to see her body led to a disconnect or tension in her system which resulted in feelings of disorientation and fear.

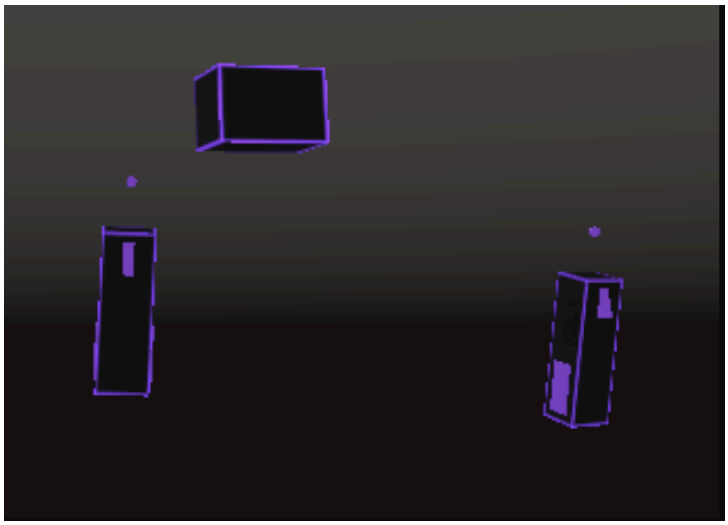

Figure 6: How one user would have seen another user's HMD and handheld controllers during Bodily Undoing. Any given user would also have been able to see their own handheld controllers through their HMD.

For bodies which are perhaps less sensitised toward how they are *felt*, or for those which are unaccustomed/unable to be felt and sensed (e.g., stroke patients who are trying to recover proprioception skills, or bodies with little or no dance-somatic training), one could imagine another response with regard to a 'knowing' of the unseen body in the VE. Marti Lahti hints at this response writing about the body of the 'gamer', who in the act of playing games emphasizes "an immaterial and disembodied vision that explores a virtual landscape with relative freedom and liberates perception (and the body)" (Wolf and Perron, 2003: 168). This is an obvious paradox, because the body, while it may be de-emphasized by the gamer, is impossible to leave behind: "if something is left behind when we play, it is not the body" (Wolf and Perron, 2003: 169). If bodies are neither *felt* (somatically) nor *seen* (virtually) then where are they situated, and what is left? Popat poses what could appear as a rather dystopian possible future in this respect, asking whether "[b]y the middle of the present century, will we be uploading our consciousness into cyberspace and leaving our obsolete bodies, or "meat," behind us?" (Popat, 2017: 360).

Balanced against this possible future, Popat offers another more optimistic path, "…Will embodied experience connect us across physical and virtual worlds?" (Popat, 2017: 360), where the body is not a limitation, but an expanded site of interconnected action, and where human bodies need not be masters. If the (human) body holds tightly to the ideologies of a human-centred world in which the human has master autonomy, and the body remains as a fixed, un-moveable entity which is defined solely by its fleshy boundaries[22], the relationship between the human and the computer becomes marked by the interface between them. This interface acts thus as a boundary-line between "the solidity of real-life on one side and the illusion of VR on the other" (Hayles, 1999: 290) forcing a division between "an inert body that is left behind and a disembodied subjectivity that inhabits the virtual realm" (Hayles, 2017: 290). On the other hand, perhaps a body which understands (and conforms) to its inherently plastic and adaptable form, and to the porous nature of its boundaries, is a body more equipped to deal with "the complex interplays that ultimately make the entire world one system" (Hayles, 1999: 290). As Hayles writes, "it is not a question of leaving the body behind but rather of extending embodied awareness in highly specific, local, and material ways that would be impossible without electronic prosthesis" (Hayles, 1999: 291).

[22] Vivian Sobchack writes from a phenomenological perspective about her personal experience of prosthetics and how she "attends to the dynamics and mutability of the supposed 'phantom' limb of her prosthetic leg" (1: 2010, Sobchack).

For some bodies, VR in fact represents a positive step toward 'embodiment'. For example, scientists in our research lab are exploring nanoscale molecular simulations within the multi-person VR framework, as a means to better understand the mechanics and motion of the molecular world. In such cases, the VR system offers an alternative interface to the traditional computer-screen and text-based work-flows which rely on seated workers, 2d screens, a mouse, and a keyboard. VR in this case offers a more intuitive medium which allows researchers to efficiently use their intuitive movement vocabularies to express their scientific and molecular intuition[23]. Enabling scientific bodies to physically move together in a space, and to interact with a range of real-time molecular structure simulations, provides a more intuitive and tangible research experience. Researchers and students alike have the chance to reinforce their (until now, purely intellectual and mathematical) understanding of molecular mechanics with a sort of 'embodied knowledge' – i.e., a somatic understanding of how different molecules 'feel', and how they 'move'. The system encourages a communication between bodies which is grounded in movement-based exchanges. The aforementioned use of VR in stroke rehabilitation therapy has shown that VR can in fact *awaken* senses – namely, proprioception. This is interesting because it runs counter to a very popular misconception that sees VR as a mechanism for shutting out sensory awareness.

6. Cultural & Technological Contexts for a Radical Rewiring

Katherine Hayles writes about "the technologies of VR, with their potential for full-body mediation" which make the notions of "presence and absence seem irrelevant", as "the avatar both is and is not present, just as the user both is and is not inside the screen" (Hayles, 1999: 26). During *Playing with Virtual Realities*, a recent conference in Berlin, we met game-designer Thorsten S. Wiedemann, who recently performed a 48-hour VR durational performance which was streamed live over the net. He talked about various aspects of the performance, including a panic attack which he suffered midway through, how he would go to sleep in a virtual cage, how he would wake up on a beach, and how he took medications to stop him needing the toilet. He described wanting to *discover himself* in the virtual space. Speaking about how the lack of any virtual bodily representation, he remarked "It doesn't matter if you don't have legs, I don't really notice my legs [day-to-day], it's just me. In VR I can be just me" (Wiedemann, 2018).

Lanier writes "Everything about you and your world can change" (55:2017, Lanier), so what is left? "You are still there, at the centre, experiencing whatever is present" (55:2017, Lanier). Can VR then be considered as a 'place' where 'difference' is transcended, where bodily constraint is freed up (in gravity-free and border-less zones), and in which consciousness and the act of being and moving – alone and together – move past the boundaries of 'body' and 'identity'? Certainly, for Wiedemann, this was the case. Imagining his train of thoughts or questions is an interesting thought experiment: where am I? who am I? what is real? do I exist? Once he had got past the panic at hour 27, we wonder whether he found new and expanded perimeters for his environment, his body, and the nature of existence and what he constituted as real. At this particular stage in our societal technological evolution, the contrast between VR and pervasive mobile technologies offers an interesting case study in terms of presence. Mobile technologies are designed to keep their users in a perpetually defocussed state, never fully present with the people and the environment in which they are situated, and never entirely focussed on the phone, but always potentially subject to distraction, to buzzing, to ringing, to notifications. This perpetually distracted state has become so familiar that it is becoming something of a cultural meme. With mobile, distraction is in is fact designed into the apps, in

[23] Scientific *intuition* is a thing, see https://doi.org/10.1080/0950069940160406

order to keep us perpetually inputting data to offer ourselves as targets for more effective tracking and advertising. It is a state of perpetual liminality. VR actually offers something completely different: a space in which the user is required (though sensory re-wiring) to be much more actively engaged in exactly *where they are* and *what they are doing*. There is therefore a sense in which VR, at this particular moment of technological evolution, offers a space to be more fully *present*. The user is either in or out of VR, without being locked into a state of perpetual liminality.

In some cases, *Bodily Undoing* workshop participants spoke about their VR experience as "unsettling" (Participant, 2017: 4) and as giving them a "sense of vulnerability" (Participant, 2017: 14). For others it was an incredibly freeing experience. Madary and Metzingers write, "[t]he conscious mind of human beings, which has evolved under very specific conditions and over millions of years, now gets causally coupled and informationally woven into technical system for representing possible realities" (20: 2016). The paradox for VR is that it has the potential to transform ways of knowing the body and for ways in which bodies can be together, but at the same time it can increase vulnerability through some loss of control. The *coupling* or layering between real and virtual environments and bodies, and the ways in which the fabric of these environments and bodies are woven together, brings a complexity to this human experience that needs to be better understood. Given the sensory re-wiring that takes place for bodies in VR, performance practices which incorporate VR technologies and systems cannot simply draw from the histories of immersive theatre, from cinema, or from other performance-based technologies. Rather they need to think more radically about the ethics of convention for participation and the implications for the bodies that are involved in these practices (see Dixon, Birringer, Salter), and draw from a wider field of knowledge and body-based practice. Madary and Metzinger argue this ethical research is undertaken in a "critical, evidence-based, and rational manner" (24: 2016).

7. Conclusions and Next Steps

The *Bodily Undoing* workshops focused on a taking dance-somatic approach to open up normative ideas around *ways of seeing* as a means by which to enter participants into a VE from a more integrated or synaesthetic sensory standpoint. The workshops drew on the notion of *seeing* as something which need not pertain exclusively to the visual apparatus of the eyes but as part of an embodied and synaesthetic interchange between a mutually permeating body and its environment. This practice brought up different responses to a body which is unseen, both by wearing the blindfold and the HMD. Fisher's notion (as aforementioned) to specify a 'Virtual Environment' (rather than a 'Virtual Reality') is to locate or situate it rather than present it as another version of 'reality' (1991). It was such the case that the *Bodily Undoing* participants very much needed to first locate themselves within the VE, and then within their own unseen bodies in the VE. Once these practices had taken place, participants then began to identify with the other bodies with whom they shared the VE. Participants were also co-located in the physical space to their (physical) partners (who were not in the VE with them), and in relation to the physicality of the technology: This was achieved through the somatic-based tasks they participated in before entering into the VE, and which included a visual, physical and tactile understanding of the physical space and one another, and the weight and physicality of the VR headsets.

Broadly speaking, the workshop participants felt more restricted when using vision to explore the physical space and interact with others (task 1), compared to wearing the blindfold (task 3):

> I really enjoyed the permission at the beginning to explore everything but I noticed that I stopped myself from exploring… then when my sight was removed I was immediately like oh yeah I really want to go there, and that now I can explore the panel and the guys hand and his face, like my normal social boundaries were let go of because I was blindfolded so I had like a reason for playing, whereas I wouldn't, didn't give myself that permission in the beginning (Participant, 2017: 1).

Furthermore, participants in the workshops responded to being in both the blindfold and the HMD by opening up *felt*-based sensory modes of perception. The process of going into a blindfold and into an HMD disrupts the senses, in particular the reliance on vision that is so prevalent and manifest in Western society. Through this disruption there is the possibility for an *awakening* of non-normative modes of perception, and subsequently a possibility for choices around ways in which the body can re-learn, through its plasticity, new modes of perception.[24] Through the disruption to her senses due to her *missing body* during her solo navigation through the VR experience *White Island,* Popat exposed a 'knowing' of her unseen body through proprioception and tactility, an effect which similarly enables stroke patients to rehabilitate proprioception. Through the *Bodily Undoing* workshop process, it was discovered that somatically trained bodies experienced their visually absent or unseen bodies in the VE in divergent ways. One set of participants *knew* their body without the need to see it in a visual form and this seemed to grant them a sense of freedom from the visual restraints that *seeing* the body brings. A second set of participants felt the need to see the body to *know* it and this second response, with an inability to see the body in the (seen, virtual) environment, brought with it sensations of dis-orientation and un-anchored-ness. Whilst these two responses are different, they both emphasize a need to know the body and come from the standpoint of somatic-based dancers and practitioners. This essay gestures to the 'gamer-participant' in VR, who might not have the same necessity to know the body and might even have a desire to leave it behind.

The notion of a thickness both in the body and in the space (in particular the space around or surrounding the body) in the VE points to the occurrence of a *felt* or *tactile* sense which correlates to the visual information presented (that which is seen or unseen). Moreover, we have noted several people from a range of backgrounds mention the fact that the different molecular simulations, which are present in the VE we are using, 'feel' differently. However, it remains unclear precisely what they mean in this usage of the word 'feel' and this is something that we will be investigating further through subsequent workshops. These next workshops will guide participants through a series of tasks which explore the ways in which physical, virtual, and imagined entities 'feel' or have a tactile presence, both in the play of the individual and through acts of passing and sharing these physical, virtual and imagined entities with others. The notion of the felt sensation or tactile presence of an entity which is non-material as a force or a touch which is invisible will be explored. This form of touch or tactility is something to which dancers and somatic practitioners are attuned, and there are practices in training such a tactile attention in contact improvisation and improvisation ensemble practices (see here the work of dancer and researcher Nita Little on training tactile attention using Contact Improvisation[25]). As a longer-term trajectory, the two-part workshop series will feed into performance-making processes which will explore how VR frameworks and environments might be *shared* as layered experiences between co-present bodies. Because the multi-person framework allows us to put groups of 6-8 people into VEs together,

[24] There is a whole area of research evolving in the field of Human-Computer-Interaction called *Somaesthetics* which foregrounds the role of bodily or *felt* experience, see this paper as an example: http://interactions.acm.org/archive/view/july-august-2015/somaesthetic-design

[25] https://doi.org/10.1386/jdsp.6.2.247_1

it opens up fascinating research opportunities for exploring how to weave together "audiences" and "performers". To date, most VR experiences are sedentary, and whilst they encourage visual-cognitive engagement with the content, the body is effectively obsolete. Through training participants using the combination of somatic practices and VR technology, a carefully constructed VR experience could actually be used to attune the participant to nuances of their body of which they may be otherwise unaware, and it is this domain that we find particularly fascinating. On a final note; an interesting phenomenon that has been observed by us and is an area which we are keen to further explore in the next workshops, is what we call the 'residue' environment. Once participants leave the VE, there is a sense of a continuing presence of that VE in the physical environment. A lingering residue, an inter-subjective imagined realm. Madary and Metzinger comment in a section entitled "Illusions of Embodiment and Their Lasting Effect" (7: 2016) about the "evidence that behaviour while in the virtual environment can have a lasting psychological impact after subjects return to the physical world" (7: 2016).

Acknowledgements

Thanks to Mike O'Connor, Balazs Hornung, Alex Jones, Simon Jones, and Kate Elswit, all of whom supported this work along the way (at the Barbican, the Arnolfini, and also during Bodily Undoing). DRG acknowledges funding from the following sources: the Royal Society (UF120381 & RG130510); EPSRC (impact acceleration award, institutional sponsorship award, and EP/P021123/1), the Leverhulme Trust (Philip Leverhulme Prize); and the London Barbican (Open Lab Funding). LMT acknowledges funding from the University of Bristol, Interactive Scientific Ltd., Royal Society, and the Leverhulme Trust.

Biographies

Lisa May Thomas (LMT) is an award-winning contemporary dance artist and film-maker trained at Laban. Her screen-dance work has been presented at film festivals globally, on digital TV channels (BBC, Channel 4, ABC), and in community and education sectors (*The Elders, Tea Time, The Touch Diaries)*. LMT has worked extensively with digital technologies in performance, including multi-award-winning sci-art-tech collaboration *danceroom Spectroscopy* digital performance *Hidden Fields* and her own research project *Dances with Avatars.* LMT is a resident at Bristol's Pervasive Media Studio, PhD candidate at the University of Bristol (joint between performance and computer science), and member of Glowacki research group.

David R. Glowacki (DRG) is a Royal Society Research Fellow at the University of Bristol, a Philip Leverhulme fellow, and visiting scholar at Stanford University. In addition to publishing widely across a range of scientific and artistic disciplines, he also works as an artist. His multi-award-winning artworks, which combine digital aesthetics with state-of-the-art interactive computing, have been experienced by over 200,000 people across three continents. In Bristol, DRG leads a cross-disciplinary academic research group whose members have expertise spanning molecular physics, computer science, human-computer interaction, virtual reality, digital audio processing, performance, and contemporary dance. DRG is a resident at Bristol's Pervasive Media Studio & co-founder of interactive Scientific Ltd.

Bibliography

ABRAM, D. 2010. *Becoming Animal: An Earthly Cosmology*, Vintage. d

ARTAUD, A. 2010. The Theatre and It's Double. Translated by Victor Corti. Oneworld Classics Ltd.

ARTUAD, A. 1958. The Theater and Its Double. Translated by Mary Caroline Richards. Grove Press Inc. New York.

BARAD, K. Mousse. *In:* KLEINMAN, A. (ed.). Summer, 2012 (edition 24).

BRAUN, V & CLARKE, V. 2006. Using Thematic Analysis in Psychology. *Qualitative Research in Psychology*, 3 (2). pp. 77-101

CHENG, L.-P., MARWECKI, S. & BAUDISCH, P. 2017. Mutual Human Actuation.

CHO et al. 2014. *Development of Virtual Reality Proprioceptive Rehabilitation System for Stroke Patients*

DE SPAIN, K. 2014. *Landscape of the Now: A Topography of Movement Improvisation*, Oxford University Press.

FISHER, S. S. 1991. Virtual Environments, Personal Simulation & Telepresence, *Virtual Reality: Theory, Practice and Promise,* S. Helsel and J. Roth, ed., Meckler Publishing.

GIBSON, R. & MARTELLI, B. 2014. *White Island* [Online]. Vimeo. [Accessed].

GLOWACKI, D.G. et al. 2018. *Sampling Molecular Conformations and Dynamics in a Multi-User Virtual Reality Framework* https://arxiv.org/abs/1801.02884

GLOWACKI, D.G. Sculpting molecular dynamics in real-time using human energy fields, *Molecular Aesthetics,* ISBN: 9780262018784 (MIT Press), ed. Peter Weibel and Ljiljana Fruk, Sept 2013

GLOWACKI, D.G. et al. 2016. danceroom Spectroscopy: at the frontiers of physics, performance, interactive art, and technology, Leonardo, 49(2), p 138-147

GRAU, O. 2003. Virtual Art: From Illusion to Immersion

HAYLES, K. N. 2017 *Unthought: The Power of the Cognitive Nonconscious*, The University of Chicago Press.

HAYLES, N. K. 1999. *How We Became Posthuman: Virtual Bodies in Cybernetics, Literature, and Informatics*, Chicago and London: The University of Chicago Press.

HOOK, J et al. 2015. *Somaesthetic Design*

KAMPE, T. Bodily Undoing. Bodily Undoing: Somatic Activism and Performing Cultures as Practices of Critique, 2017. Bath Spa University.

LANIER, J. 2017. Dawn of the New everything. The Bodley Head, London

MADARY, M & METZINGER, T.K. 2016. Real Virtuality: A Code of Ethical Conduct. Reccommendations for Good Scientific Practice and the Consumers of VR-Technology: Frontiers in Robotics and AI, *Vol. 3 (article 3).*

MONTAGUE, A. 1986. Touching: The Human Significance of the Skin

PAXTON, S. 2015. Why Standing? *Contact Quarterly,* Winter-Spring.

POPAT, S. 2016. Missing in Action: Embodied Experience and Virtual Reality. *Theatre Journal,* 68**,** pp. 357-378.

POPAT, S. 2017. Bodily Extensions and performance. *International Journal of Performance Arts and Digital Media,* 13**,** 101-104.

SACKS O. 1985. The Man Who Mistook His Wife for a Hat and Other Clinical Tales. Gerald Duckworth.

SANCHEZ-VIVES. M.V. & SLATER, M. 2005. From Presence to Consciousness through Virtual Reality. *Perspectives, 6, 332-339*.

SOBCHACK, V. 2010. Living a 'Phantom Limb': On the Phenomenology of Bodily Integrity. *Body and Society Vol. 16(3): 51-67*

SLATER, M. 2010. First Person Experience of Body Transfer in Virtual Reality

SUTHERLAND, I. 1965. *The Ultimate Display*

THOMAS, L. M. 2017. Bodily Undoing dance and VR workshops: My Body is Always the Rover. *In:* THOMAS, L. M. (ed.) *Bodily Undoing*.

VERTESI, J. 2015. *Seeing Like a Rover*, Chicago & London: The University of Chicago Press.

WIEDEMANN, T. *Playing with Virtual Realities* Symposium, Dock11, Berlin. Jan 2018.

WOLF, M. J. P. & PERRON, B. (eds.) 2003. *The Video Game Theory Reader*: Routledge.